Ministry of Higher Education
Giza Higher Institute for Eng. & Tech.
Civil Engineering Department
Course Name: Computer Applications in Civil Eng.
Course Code : **CIV 410**

Academic Year : **2013–2014**
Semester : **Second**
Level : **4th**
Time : **3 Hours**
Date : **11 / 6 / 2014**
Examiner: ***Dr. M. Abdel-Kader***

Second Semester Final Examination

- Attempt all questions.
- The Exam consists of **4** questions in **2** pages.
- Maximum grade is **60 Marks**.

Question (1): (10 Marks)

(a) Choose the correct answer (**Put a, b, c or d in front of the statement number in your answer paper**).

1.	c
2.	a
3.	d
4.	c
5.	c

(b) **TRUE or FALSE** (**Put ✓ or ✗ in front of the statement number in your answer paper**)

1.	✗
2.	✗
3.	✓
4.	✓
5.	✓

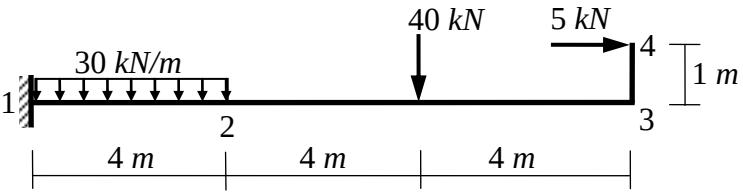
Question (2): (10 Marks)

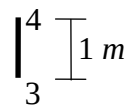
The matrix equilibrium equation of the shown structure is:

$$\{F\} = [K]\{\Delta\} + \{F^f\}$$

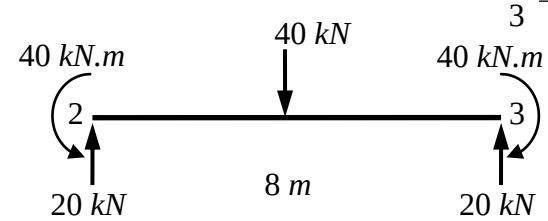
Write

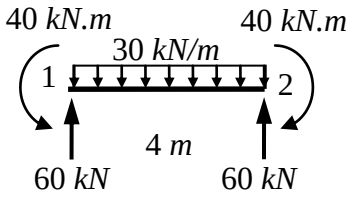
- The nodal forces vector $\{F\}$
- The nodal displacements vector $\{\Delta\}$
- The fixed end solution $\{F^f\}$





$$\{F\} = \begin{matrix} 1 \\ \\ \\ 2 \\ \\ \\ 3 \\ \\ \\ 4 \\ \\ \end{matrix} \begin{Bmatrix} X_1 \\ Y_1 \\ M_1 \\ \hline 0 \\ 0 \\ 0 \\ \hline 0 \\ 0 \\ 0 \\ \hline 5 \\ 0 \\ 0 \end{Bmatrix} \quad \{\Delta\} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ \hline u_2 \\ v_2 \\ \theta_2 \\ \hline u_3 \\ v_3 \\ \theta_3 \\ \hline u_4 \\ v_4 \\ \theta_4 \end{Bmatrix} \quad \{F^f\} = \begin{Bmatrix} 0 \\ 60 \\ 40 \\ \hline 0 \\ 80 \\ 0 \\ \hline 0 \\ 20 \\ -40 \\ \hline 0 \\ 0 \\ 0 \end{Bmatrix}$$





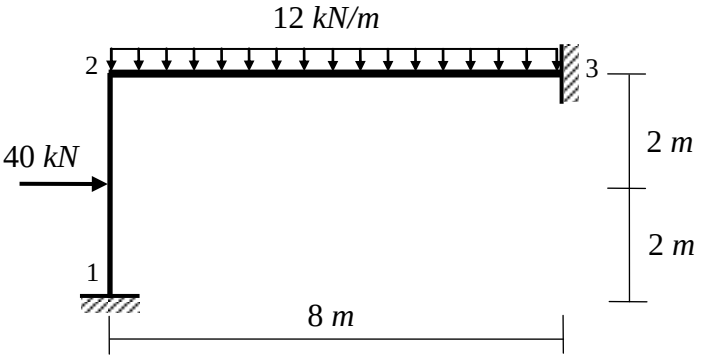
Question (3): (20 Marks)

For the shown frame, using the stiffness method:

Neglect axial deformation

(a) Determine the displacements at the nodes due to the given load.

(b) Draw the bending moment diagram.



Given Data:

$E = 2.1\times10^{7}\ kN/m^2$ $A = 0.15\ m^2$ $I = 3.125\times10^{-3}\ m^4$

Element (1): (nodes 1 & 2)

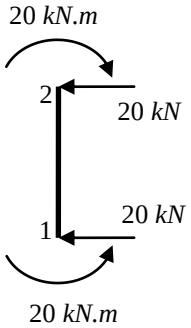
$\lambda = \cos\alpha = 0$ and $\mu = \sin\alpha = 1$

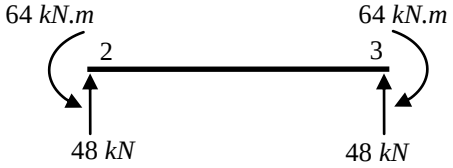
$6EI/L^2 = 6 \times 2.1\times10^{7} \times 3.125\times10^{-3} / 4^2 = 24609$

$4EI/L = 4 \times 2.1\times10^{7} \times 3.125\times10^{-3} / 4 = 65625$

$2EI/L = 32813$

$$\begin{Bmatrix} X_1 \\ Y_1 \\ M_1 \\ F_{x2} \\ F_{y2} \\ M_2 \end{Bmatrix} = \begin{bmatrix} - & - & - & - & - & -24609 \\ - & - & - & - & - & 0 \\ - & - & - & - & - & 32813 \\ - & - & - & - & - & 24609 \\ - & - & - & - & - & 0 \\ - & - & - & - & - & 65625 \end{bmatrix} \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \theta_2 \end{Bmatrix} + \begin{Bmatrix} -20 \\ 0 \\ 20 \\ -20 \\ 0 \\ -20 \end{Bmatrix}$$





Fixed End Solution

Element (2): (nodes 2 & 3)

$\lambda = \cos\alpha = 1$ and $\mu = \sin\alpha = 0$

$6EI/L^2 = 6 \times 2.1\times10^{7} \times 3.125\times10^{-3} / 8^2 = 6152$

$4EI/L = 4 \times 2.1\times10^{7} \times 3.125\times10^{-3} / 8 = 32813$

$2EI/L = 16406$

$$\begin{Bmatrix} F_{x2} \\ F_{y2} \\ M_2 \\ X_3 \\ Y_3 \\ M_3 \end{Bmatrix} = \begin{bmatrix} - & - & 0 & - & - & - \\ - & - & 6152 & - & - & - \\ - & - & 32813 & - & - & - \\ - & - & 0 & - & - & - \\ - & - & -6152 & - & - & - \\ - & - & 16406 & - & - & - \end{bmatrix} \begin{Bmatrix} 0 \\ 0 \\ \theta_2 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + \begin{Bmatrix} 0 \\ 48 \\ 64 \\ 0 \\ 48 \\ -64 \end{Bmatrix}$$

Frame equation

$$\begin{Bmatrix} X_1 \\ Y_1 \\ M_1 \\ 0 \\ 0 \\ 0 \\ X_3 \\ Y_3 \\ M_3 \end{Bmatrix} = \begin{bmatrix} - & - & - & - & - & -24609 & - & - & - \\ - & - & - & - & - & 0 & - & - & - \\ - & - & - & - & - & 32813 & - & - & - \\ - & - & - & - & - & (24609+0) & - & - & - \\ - & - & - & - & - & (0+6152) & - & - & - \\ - & - & - & - & - & (65625+32813) & - & - & - \\ - & - & - & - & - & 0 & - & - & - \\ - & - & - & - & - & -6152 & - & - & - \\ - & - & - & - & - & 16406 & - & - & - \end{bmatrix} \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \theta_2 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + \begin{Bmatrix} -20 \\ 0 \\ 20 \\ -20 \\ 48 \\ 44 \\ 0 \\ 48 \\ -64 \end{Bmatrix}$$

From Row No. 6 → $0 = (65625+32813)(\theta_2) + 44$ → $\theta_2 = -4.47\times10^{-4}$ rad

From Element 1

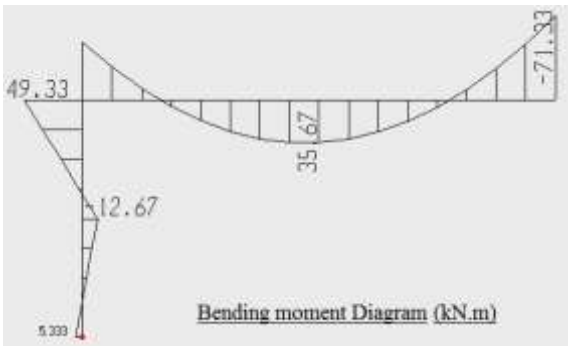
$M_1 = 32813\ (-4.47\times10^{-4}) + 20 = +5.333\ kN.m$

$M_2 = 65625\ (-4.47\times10^{-4}) - 20 = -49.334\ kN.m$

From Element 2

$M_2 = 32813\ (-4.47\times10^{-4}) + 64 = +49.333\ kN.m$

$M_3 = 16406\ (-4.47\times10^{-4}) - 64 = -71.333\ kN.m$

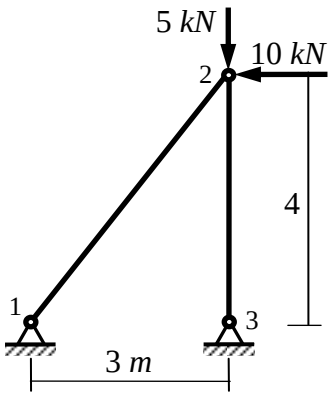


Question (4): (20 Marks)

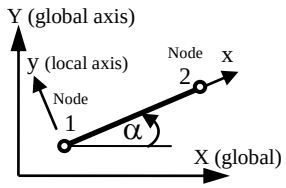
For the shown truss, using the stiffness method:

(a) Determine the displacements at the nodes due to the given load.

(b) Determine the reactions at the supports.



Given Data: $E = 2.0\times10^{7}\ kN/m^2$ $A = 2.0\times10^{-4}\ m^2$



Truss (Bar) element

$$[K_e]=\begin{bmatrix} \frac{EA}{L}\lambda^2 & \frac{EA}{L}\mu\lambda & -\frac{EA}{L}\lambda^2 & -\frac{EA}{L}\mu\lambda \\ \frac{EA}{L}\mu\lambda & \frac{EA}{L}\mu^2 & -\frac{EA}{L}\mu\lambda & -\frac{EA}{L}\mu^2 \\ -\frac{EA}{L}\lambda^2 & -\frac{EA}{L}\mu\lambda & \frac{EA}{L}\lambda^2 & \frac{EA}{L}\mu\lambda \\ -\frac{EA}{L}\mu\lambda & -\frac{EA}{L}\mu^2 & \frac{EA}{L}\mu\lambda & \frac{EA}{L}\mu^2 \end{bmatrix}$$

Where, $\lambda = \cos\alpha$ and $\mu = \sin\alpha$

Element (1): (nodes 1 & 2)

$\lambda = \cos\alpha = 0.6$ and $\mu = \sin\alpha = 0.8$

$EA/L = 2.0\times10^{7} \times 2.0\times10^{-4} /5 = 800$

$$\begin{Bmatrix} X_1 \\ Y_1 \\ F_{x2} \\ F_{y2} \end{Bmatrix} = \begin{bmatrix} 288 & 384 & -288 & -384 \\ 384 & 512 & -384 & -512 \\ -288 & -384 & 288 & 384 \\ -384 & -512 & 384 & 512 \end{bmatrix} \begin{Bmatrix} 0 \\ 0 \\ u_2 \\ v_2 \end{Bmatrix}$$

Element (2): (nodes 2 & 3)

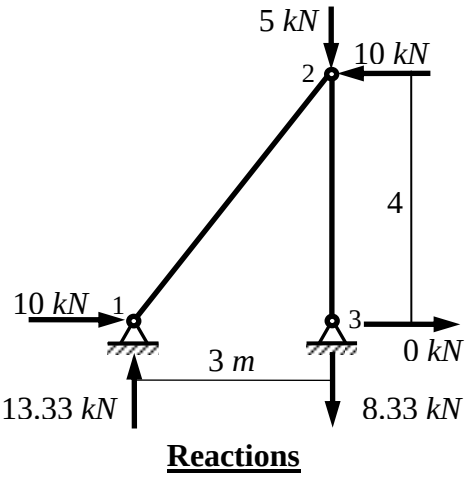
$\lambda = \cos\alpha = 0$ and $\mu = \sin\alpha = -1$

$EA/L = 2.0\times10^{7} \times 2.0\times10^{-4} /4 = 1000$

$$\begin{Bmatrix} F_{x2} \\ F_{y2} \\ X_3 \\ Y_3 \end{Bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1000 & 0 & -1000 \\ 0 & 0 & 0 & 0 \\ 0 & -1000 & 0 & 1000 \end{bmatrix} \begin{Bmatrix} u_2 \\ v_2 \\ 0 \\ 0 \end{Bmatrix}$$

Truss equation

$$\begin{Bmatrix} X_1 \\ Y_1 \\ -10 \\ -5 \\ X_3 \\ Y_3 \end{Bmatrix} = \begin{bmatrix} 288 & 384 & -288 & -384 & 0 & 0 \\ 384 & 512 & -384 & -512 & 0 & 0 \\ -288 & -384 & (288+0) & (384+0) & 0 & 0 \\ -384 & -512 & (384+0) & (512+1000) & 0 & -1000 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1000 & 0 & 1000 \end{bmatrix} \begin{Bmatrix} 0 \\ 0 \\ u_2 \\ v_2 \\ 0 \\ 0 \end{Bmatrix}$$



Reactions

From Row No. 3 → $-10 = (288)(u_2) + (384)(v_2)$

From Row No. 4 → $-5 = (384)(u_2) + (1512)(v_2)$ → $u_2 = -0.04583\ m$ and $v_2 = 0.008333\ m$

From Row No. 1 → $X_1 = -288(-0.04583) - 384(0.008333) = 10\ kN$ → $X_1 = 10\ kN \rightarrow$

From Row No. 2 → $Y_1 = -384(-0.04583) - 512(0.008333) = 13.33\ kN$ → $Y_1 = 13.33\ kN \uparrow$

From Row No. 5 → $X_3 = 0(-0.04583) + 0(0.008333) = 0$ → $X_3 = 0$

From Row No. 6 → $Y_3 = 0(-0.04583) - 1000(0.008333) = -8.33\ kN$ → $Y_3 = 8.33\ kN \downarrow$

With my best wishes

Dr. M. Abdel-Kader